

ESTIMATED GROUNDWATER IMPACTS ASSOCIATED WITH BOTTOM SEDIMENT REMOVAL FROM LOWER LAKE PRIOR TO IN-SITU TREATMENT OF LOWER LAKE FLUIDS

As shown on the enclosed figure, approximately 2 feet of sludge plus 2 feet of natural bottom deposits are to be dredged from Lower Lake. Since this action will result in reduced fine grained materials underlying the pond, an increased leakage rate from the pond to groundwater will probably occur.

Several factors will contribute to increased leakage from the pond:

1. Dredging will reduce the thickness of fine grained materials from about 12 feet to about 8 feet. Even if it is assumed the sediments have uniform permeability throughout the sediment profile, which is unlikely, reduced thickness by itself also will result in increased leakage from the pond.
2. Dredging will remove much of the finest grained materials and therefore materials with the lowest permeabilities. Based on field observations, drill logs and stratigraphic cross-sections (see attached figure), the finest sediments are within the 2 to 4 foot layer which will be dredged from the pond bottom. It is possible, this layer is a significant factor inhibiting pond leakage, and underlying materials are less permeable allowing larger leakage rates.

There is insufficient data to quantify leakage losses based on the removal of shallow materials, which may have lower permeability values than deeper materials which would remain (Item 2 above). Therefore, theoretical leakage rates based on conditions described in Item 1 only are calculated.

Estimates of future groundwater impacts as a result of bottom sediment removal prior to in-situ treatment of Lower Lake fluids are calculated using the same approach outlined in the Process Ponds RI/FS. Based on loading calculations in the RI, present leakage losses to groundwater (before sediment removal) were estimated to be 22 gallons per minute (gpm). Based on this leakage rate, the average permeability of fine grained sediment underlying the pond was calculated using the equation modified from evaluation (1970):

$$Q_L = \frac{P' Dh A_L}{M}$$

Where:

Q_L	=	seepage in underlying strata
P'	=	vertical permeability of underlying strata
M'	=	thickness of underlying strata below pond and above the underlying saturated gravels
A_L	=	area of strata underlying the lake through which seepage occurs

Dh = difference in head between the pond surface and the groundwater level observed in nearby well DH-4

Solving for P' , the average permeability of the underlying fine-grained strata was calculated to be 3.5×10^{-6} cm/s (Hydrometrics 1989). This value compares with remolded laboratory permeability values of 1.9×10^{-6} and 8.1×10^{-8} cm/s. The sample intervals used for laboratory permeability tests were 7 to 16.5 feet and 9 to 18 feet below the pond surface. (see enclosed figure). Since laboratory permeability measurements were limited to drill holes with sufficient sample for analysis, and therefore were conducted using samples with the most silt and clay content, laboratory permeability values are probably less than the average for sediments underlying the pond.

Leakage estimates after sediment dredging are calculated below using the average permeability estimate values from the Process Pond RI/FS. Assuming an average permeability of 3.5×10^{-6} throughout the sediment profile, and assuming 4 of the 12 feet of fine grained materials will be removed resulting in a reduced fine-grained thickness of 8 feet, leakage losses are calculated as follows:

$$\frac{Q_L = P' Dh A_L}{M'} = \frac{.078 \text{ gpd/ft}^2 \times 16 \text{ ft} \times 304920 \text{ ft}^2}{8 \text{ ft}}$$

$Q = 32 \text{ gpm}$

Water quality impacts associated with increased leakage rates are also calculated below using the same procedure presented in the Process Ponds RI/FS. Water quality arsenic concentrations immediately adjacent to Lower Lake are calculated as follows:

$$F_a C_a + F_L C_L = F_b C_b$$

Where: $F_a C_a$ = arsenic load in groundwater or surface water upgradient or above Lower Lake

$F_L C_L$ = arsenic load in water seeping from Lower Lake to groundwater or surface water

$F_b C_b$ = arsenic load in groundwater or surface water downgradient or areally below Lower Lake

F = Flow gpm

C = arsenic concentration mg/L

In Fall 1989, the typical arsenic concentration for Lower Lake was 25 mg/l. Assuming similar concentrations after sediment removal, calculated arsenic concentrations in groundwater are:

$$C_b = \frac{111 \text{ gpm} (0.014 \text{ mg/L}) + 32 \text{ gpm} (25 \text{ mg/L})}{111 \text{ gpm}} = 7.2 \text{ mg/L}$$

This compares with a pre-removal concentration value of about 4 mg/l in monitoring well DH-4, which is located immediately adjacent to Lower Lake.

An additional factor to consider is improvement of water quality in Lower Lake as a result of reduced use as a storage pond. Water quality results from December 1990 showed significant reduction in Lower Lake arsenic concentrations from 25 mg/l to 13 mg/l. Assuming Lower Lake concentrations at the time of sediment removal are 13 mg/l, calculated groundwater concentrations after removal are:

$$C_b = \frac{111 \text{ gpm} (0.014 \text{ mg/L}) + 32 \text{ gpm} (13 \text{ mg/L})}{111 \text{ gpm}} = 3.8 \text{ mg/L}$$

Based on the assumptions used in the calculations, significant increases in pond leakage rates and groundwater arsenic concentrations are not expected. However, these calculations are best estimates only, and are based on assumptions described in Item 1 above. The most critical of these assumptions is the permeability of the fine-grained strata underlying the pond is uniform through the entire sediment profile. Based on drill logs, and the attached figure, this assumption may be conservative. Some of the finest grained materials and therefore lowest permeability materials will be removed during dredging of the upper 4 feet of sediments. Leakage rates and, therefore, groundwater quality impacts may be larger than the calculated estimates presented here.

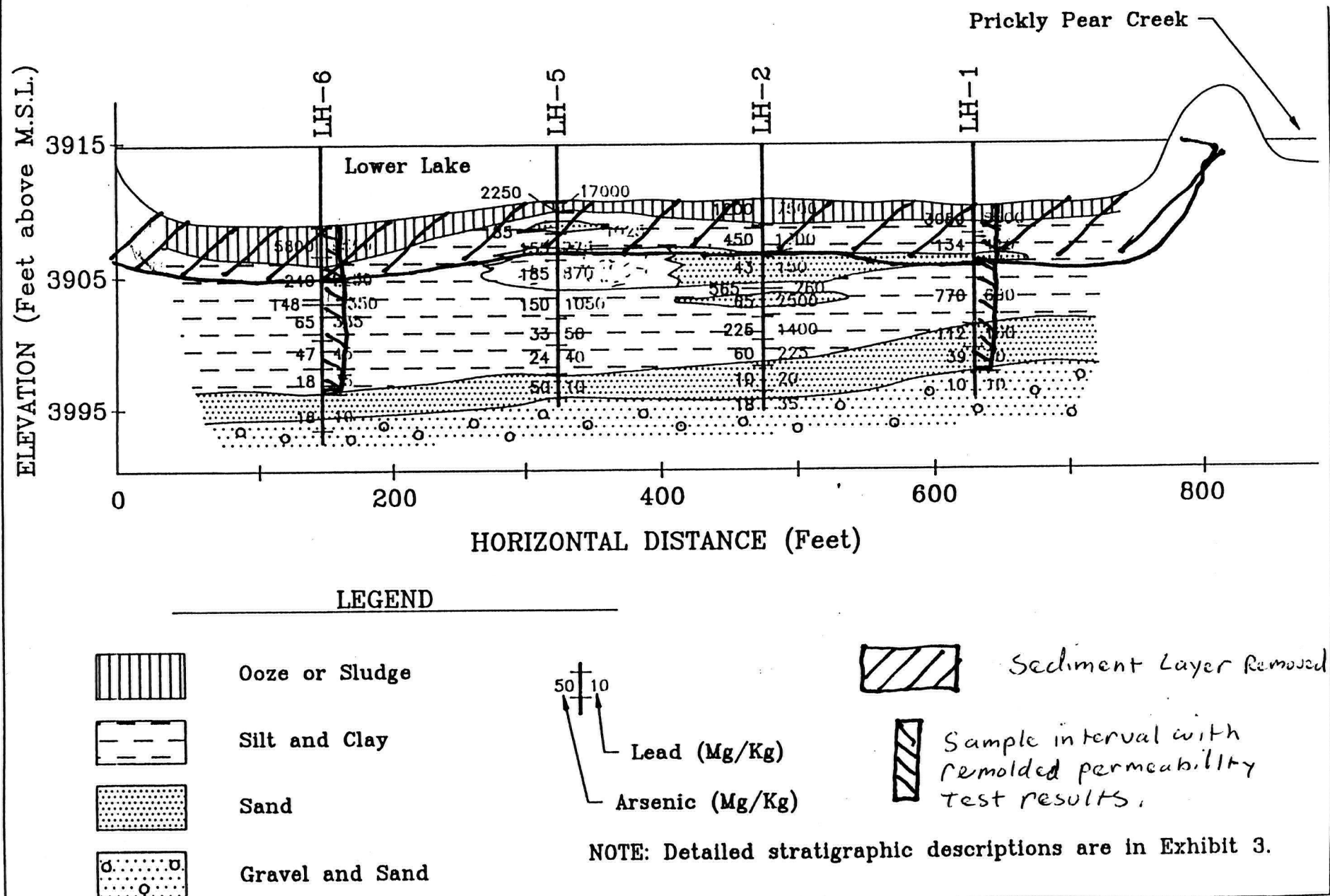


Figure 3-4. Chemical Profile and Stratigraphic Comparison For Lower Lake